

## THERMOPLASTIC MOLDING PROCESS AND APPARATUS

### 1 BACKGROUND OF THE INVENTION

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3       The present invention relates to a thermoplastic  
4 molding process and apparatus and especially to a  
5 thermoplastic process and apparatus using a  
6 thermoplastic extrusion die having adjustable gates  
7 for varying the thickness of the extruded material,  
8 which material is molded as it is passed from the  
9 extrusion die.

10       In the past it has been common to provide a wide  
11 variety of molding systems including the molding of a  
12 thermoplastic resin or a thermoplastic composite part.  
13 In vacuum molding, a slab of heated thermoplastic  
14 material is placed on the vacuum mold and a vacuum  
15 drawn between the mold and the heated plastic material  
16 to draw the plastic material onto the mold. Similarly,  
17 a compression molded part feeds a heated slab of  
18 thermoplastic material, such as a sheet of material,  
19 between two molding forms which compresses the  
20 material in the mold.

21       The present invention is directed towards a  
22 molding system for producing a thermoplastic resin of  
23 thermoplastic composite parts using either a vacuum or  
24 compression mold with parts being fed directly to the  
25 molds from an extrusion die while the thermoplastic  
26 slab still retains the heat used in heating the resins  
27 to a fluid state for forming the sheets of material  
28 through the extrusion die.

29       Prior U.S. patents which use thermoforming of  
30 material can be seen in the four Winstead patents,  
31 Nos. 4,420,300; 4,421,712; 4,413,964; and 3,789,095.  
32 The Winstead '712 and '300 patents are for an  
33 apparatus for continuous thermoforming of sheet

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1 material including an extruder along with stretching  
2 means and a wheel having a female mold thereon and a  
3 plurality of plug-assist means interlinked so as to  
4 form an orbiting device having a plug-assist member  
5 engaging the sheet material about a substantial arc of  
6 wheel surface. The Winstead '964 patent teaches an  
7 apparatus for continuously extruding and forming  
8 molded products from a web of thermoplastic material  
9 while continuously separating the product from the  
10 web, stacking and handling the products, and recycling  
11 the web selvage for further extrusion. The apparatus  
12 uses multiple mold cavities in a rotating polygon  
13 configuration over a peripheral surface of which the  
14 biaxially oriented web is continuously positioned by  
15 a follower roller interfacing the polygon with a  
16 biaxial orientation device. The Winstead patent No.  
17 3,789,095 is an integrated method of continuously  
18 extruding low density form thermoplastic material and  
19 manufacturing three-dimensional formed articles  
20 therefrom.

21 The Howell U.S. patent, No. 3,868,209, is a twin  
22 sheet thermoformer for fabricating a hollow plastic  
23 object from a pair of heat-fusible thermoplastic  
24 sheets which are serially moved in a common horizontal  
25 plane from a heating station to a mold mechanism at a  
26 forming station. The Held, Jr. patent, No. 3,695,799,  
27 is an apparatus for vacuum forming hollow articles  
28 from two sheets of thermoplastic material by passing  
29 the sheets of material through a heating zone while in  
30 a spaced relationship and between two mold halves.  
31 The mold halves are brought together as a vacuum is  
32 pulled on each sheet to cause it to conform to the  
33 shape of its respective mold so as to mold a hollow  
34 article. The Budzynski et al., No. 5,551,860, is a

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1 blow molding apparatus for making bottles which have  
2 rotating molds continuously rotating while aligning  
3 one mold at a time with an extrusion die handle for  
4 loading the mold. The Hujik patent, No. 3,915,608, is  
5 an injection molding machine for multi-layered shoe  
6 soles which includes a turntable for rotating a  
7 plurality of molds through a plurality of work  
8 stations for continuously molding shoe soles. The  
9 Ludwig patent, No. 3,302,243, is another apparatus for  
10 injection molding of plastic shoes. The Lameris et  
11 al. patent, No. 3,224,043, teaches an injection  
12 molding machine having at least two molds which can be  
13 rotated for alignment with plastic injecting nozzles.  
14 The Vismara patent, No. 4,698,001, is a machine for  
15 manufacturing molded plastic motorcycle helmets and  
16 which uses a compression type mold in which a pair of  
17 mold halves is shifted between positions. The Krumm  
18 patent, No. 4,304,622, is an apparatus for producing  
19 thick slabs of thermoplastic synthetic resins which  
20 includes a pair of extruders, each extruding a half  
21 slab strand to a respective roller assembly. The  
22 roller assemblies have final rollers which form a  
23 consolidation nip between them in which the two half  
24 slabs are bonded together.

25 The present invention is directed towards a  
26 continual thermoforming system which is fed slabs of  
27 thermoplastic material directly from an extruder  
28 forming the slabs of material onto a mold which can be  
29 rotated between stations. The thermoplastic material  
30 is extruded through an extrusion die which is  
31 adjustable for providing deviations from a constant  
32 thickness plastic slab to a variable thickness across  
33 the surface of the plastic slab. The variable  
34 thickness can be adjusted for any particular molding

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1 run or can be continuously varied as desired. This  
2 allows for continuous molding of thermoplastic  
3 material having different thicknesses across the  
4 extruded slab and through the molded part to control  
5 the interim part thickness of the molded part so that  
6 the molded part can have thick or thin spots as  
7 desired throughout the molded part.

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9 SUMMARY OF THE INVENTION

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11 A thermoplastic molding system includes a  
12 thermoplastic extrusion die for the extrusion of a  
13 thermoplastic slab. The extrusion die has adjustable  
14 die gate members for varying the thickness of the  
15 extruded material in different parts of the extruded  
16 slab. The thermoplastic extrusion die has a trimmer  
17 for cutting the extruded thermoplastic slab from the  
18 thermoplastic extrusion die. A plurality of  
19 thermoplastic molds, which may be either vacuum or  
20 compression molds, are each mounted on a movable  
21 platform, such as a rotating platform, for moving one  
22 mold at a time into a position to receive a  
23 thermoplastic slab being trimmed from the  
24 thermoplastic extrusion die. A molded part is formed  
25 with a variable thickness from a heated slab of  
26 thermoplastic material being fed still heated from the  
27 extrusion die. A plurality of molds are mounted to a  
28 platform to feed one mold into a loading position for  
29 receiving a thermoplastic slab from the extrusion die  
30 and a second mold into a release position for removing  
31 the formed part from the mold. The platform may be a  
32 shuttle or a rotating platform and allows each molded  
33 part to be cooled while another molded part is  
34 receiving a thermoplastic slab. A thermoplastic

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DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figures 1 and 2 of the drawings, a thermoforming apparatus 10 for thermoforming parts from a thermoplastic resin or from a thermoplastic composite is illustrated having an extruder 11, a mold exchange station 12, and a compression mold station 13. The extruder has a hopper 14 mounted on top for feeding a thermoplastic resin or composite material into an auger 15 where heaters are heating the thermoplastic material to a fluid material while the auger is feeding it along the length of the extruder path to an extrusion die 16 at the end thereof. The material being fed through the extruder and out the extrusion die is cut with a trimmer 17 mounted at the end of the die. The material is extruded in a generally flat plate slab and is trimmed at predetermined points by the trimmer 17 at it leaves the extrusion die. A support platform 18 will support a traveling mold half 19 directly under the extrusion die for receiving a slab of thermoplastic material. The traveling mold half has wheels 20 which allow the mold half to be moved from the platform 18 onto a rotating platform 21 mounted on a central rotating shaft 22. The rotating platform 21 will have a second mold half 23 thereon which can be fed into the compression molding station 13 while the mold half 19 is on the platform 18. The mold half 23 can be supported on a stationary platform 24 in the compression station directly beneath a common posing fixed mold half 25 mounted to a moving platen 26 where the molding operation takes place. Thus, the mold halves 19 and 23 can shuttle back and forth so that one mold can be capturing a thermoplastic slab while

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1 thermoplastic material. In Figure 3E, the mold <sup>19</sup>~~B~~ is  
2 press cooled and the part is ejected while mold <sup>23</sup>~~A~~ is  
3 charged with a hot melt as it is moved by its carrier  
4 below the extrusion die until completely charged.

5 Turning to Figures 4 and 5, the extrusion die 30  
6 is illustrated having the die body 31 having the  
7 channel 32 for the feeding of a fluid thermoplastic  
8 material with the auger 15 of Figures 1 and 2  
9 therethrough out the extrusion channel 33 to produce  
10 a sheet or slab of thermoplastic extruded material  
11 from the mouth 34. The die has a plurality of gated  
12 plates 35 each connected to a threaded shaft 36 driven  
13 by a gate actuator motor 37 which can be a hydraulic  
14 or pneumatic motor but, as illustrated, is an  
15 electrical stepper motor having a control line 38  
16 feeding to a remote controller 40 which can step the  
17 motor 37 in steps to move the plate 35 in and out to  
18 vary the thickness of the thermoplastic slab passing  
19 the channel portion 41. A plurality of any number of  
20 motors 37 can be seen in Figure 5 driving a plurality  
21 of plates, each mounted abutting the next plate, and  
22 each plate controlled separately to thereby vary the  
23 plates 35 in the channel 41 in a wide variety of  
24 patterns for producing a slab out the output portion  
25 34 having thicknesses which can vary across the width  
26 of the extruded slab. It will also be clear that the  
27 gates 35 can be manually controlled by individually  
28 threading each gate into and out to adjust the  
29 thickness of any portion of the extrusion die and can,  
30 alternatively, be controlled by a controller 40 which  
31 can be a computer program to vary the thickness of any  
32 portion of the extruded slab under remote control as  
33 desired.

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1 A thermoplastic molding process is provided which  
2 includes selecting a thermoplastic extrusion die 16 or  
3 30 for the extrusion of a thermoplastic slab, which  
4 extrusion die has an adjustable die gate members for  
5 varying the thickness of the extruded material in  
6 different parts of the extruded slab. The process  
7 includes adjusting the thermoplastic extrusion die for  
8 various thicknesses of the extruded material passing  
9 therethrough in different parts of the extruded slab  
10 and then heating a thermoplastic material to a fluid  
11 and extruding a slab of fluid thermoplastic material  
12 through the selected and adjusted thermoplastic  
13 extrusion die. The thermoplastic slab is then trimmed  
14 and directed onto a heated thermoplastic material into  
15 a thermoforming mold 19 or 23 and molded in a molding  
16 apparatus 13 to form a part with a variable thickness  
17 in the part.

18 It should be clear at this time that a  
19 thermoplastic molding process and apparatus have been  
20 provided which allow for the thermoforming of a part  
21 with a variable thickness with an extrusion die which  
22 can be continuously controlled to vary the thickness  
23 of different parts of the extruded slab being molded  
24 and that the molding is accomplished while the  
25 thermoplastic slab is still heated to utilize the heat  
26 energy from the extrusion process. However, it should  
27 also be clear that the present invention is not to be  
28 considered limited to the forms shown which are to be  
29 considered illustrative rather than restrictive.

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